MATTRESS HAVING RETICULATED VISCOELASTIC FOAM

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MATTRESS HAVING RETICULATED VISCOELASTIC FOAM

The present invention relates to foam mattresses, and specifically foam mattresses made, at least in part, from reticulated, viscoelastic foam.

Background of the Invention

Foam mattresses generally have been well known for many years. Standard polyurethane foam materials provide good cushion. The specific polyurethane material may be varied to make a mattress softer or firmer. Traditional polyurethane foam mattresses are known for their springy and bouncy nature.

Another well-known material for use in foam mattresses is viscoelastic foam. This foam, also referred to as "memory/slow recovery" foam, has low resilience and naturally shapes or conforms to a person's body. This particular foam material is also effective to dampen sound and vibration. While viscoelastic foam is very popular for use as a mattress or component thereof, a major drawback to it is its inability to "breathe". A person may overheat and excessively perspire, because there is insufficient ventilation in the foam to allow air and moisture flow. Also, the slow recovery aspect of the foam may make turning over difficult or getting out of a bed difficult. The viscoelastic foam is also very sensitive to temperature and humidity.

Foam mattresses are also known that have multiple layers and/or zones that are made up of different foam materials. In this way, different

foams are directed to specific purposes such as support or softness. Many of these multiple zone and multiple layer mattresses are one-sided (cannot be flipped) or uni-directional (cannot be turned around).

Summary

Accordingly, it is an object of the present invention to overcome the foregoing drawbacks and to provide a foam mattress that includes a reticulated, viscoelastic foam. The mattress may have multiple zones and multiple layers. The reticulated nature of the viscoelastic foam allows a user to enjoy the benefits of the softness and conformability of a viscoelastic foam and also an unprecedented breathability.

In one example, a foam mattress comprises a reticulated, viscoelastic foam, wherein the viscoelastic foam is comprised of at least about 15% by weight of a viscoelastic polyol. The foam mattress may comprise a plurality of layers of foam, and one of the layers may comprise the reticulated, viscoelastic foam. The foam mattress may also comprise a plurality of zones of foam, and one of the zones of foam may comprise the reticulated viscoelastic foam. The mattress may comprise three or more layers of foam, and an outside layer comprises the reticulated, viscoelastic foam. The outside layer of the mattress may cover substantially the entire length and width of the mattress. In a multiple layer mattress, a first layer may comprise a reticulated viscoelastic foam and a second layer may comprise a reticulated polyurethane foam, and the reticulated viscoelastic and

reticulated polyurethane foams are adhered to each other. The viscoelastic foam may be comprised of about 15% to about 75% by weight of viscoelastic polyol, or, in another example, about 60% to about 70% by weight of viscoelastic polyol. In further examples, the foam mattress may comprise at least three layers of foam and/or at least three zones of foam. The mattress may have a symmetrical layer construction and/or a symmetrical zone construction. Still further alternatively, the foam mattress may comprise five layers of foam, wherein the outside layers of foam comprise latex, the layers immediately adjacent the outside layers comprise viscoelastic foam, and a central layer comprises reticulated polyurethane foam.

Brief Description of the Drawings

Figure 1 is a side elevation view of an embodiment of a symmetric, multiple zone, five-layer foam mattress.

Figure 2 is a side-elevation view of a three-layer, multiple zone foam mattress.

Figure 3 is a side elevation view of another three-layer, multiple zone foam mattress.

Detailed Description

The foam mattress discussed herein include the use of a reticulated, viscoelastic foam alone and as a component in a composite mattress. By the

process of reticulation, a viscoelastic foam can achieve enhanced ventilation properties, thereby making it more attractive for use as a mattress or a part thereof.

For the purposes of discussion herein, the term “viscoelastic foam” means foam formed using a viscoelastic polyol, and specifically at least about 15% by weight of the viscoelastic polyol in the finished foam. Less than about 15% by weight of viscoelastic polyol does not process well, and it is believed that the resulting foam does not have significant viscoelastic properties. Weight percent ranges of viscoelastic polyol in the finished foam include about 15% to about 75%, and, for a further example, about 60% to about 70%.

The term “reticulated viscoelastic foam” means a viscoelastic foam that has been subjected to a reticulation process. Reticulation is a means by which the thin window membranes are removed from a foam to create an open cell structure that is opened to air and moisture flow. The process of reticulation involves placing a block of foam into a reticulation chamber, evacuating the chamber under vacuum to remove the air from the chamber and from within the foam, filling the chamber and foam with hydrogen and oxygen to a fuel loading of a predetermined ratio of hydrogen/oxygen to a specific pressure, and then igniting the fuel mixture to create an explosive wave that removes the membranes of the foam by pressure and heat. In addition to creating an open cell structure that allows flow through the

foam, the reticulation process also increases the strength properties of the foam.

Viscoelastic Formulation Technology

Viscoelastic or "memory/slow recovery" foams have a number of very unique performance characteristics. This high quality foam tends to be low resilience, shape or body conforming, and able to dampen both sound and vibration or shock. In addition, this material is sensitive to both temperature and humidity conditions in the ambient environment.

These foams can be produced by a number of different chemical approaches. In general these formulations will certainly include a high hydroxyl polyether polyol and a number of potential isocyanate compounds to include MDI, TDI (80/20) and TDI (65/35) and blends thereof. The products are usually foamed at low isocyanate index with special silicone surfactants to control cell structure and unique additives to operate in a mixture very different from conventional polyether urethane materials. These specialty silicone additives will assist in the cell opening process as well as control the overall structure of the urethane cells. The low index will promote cell opening as well as restrain the foam from shrinkage on curing. The formulation at a low isocyanate index will also give the resultant foam a very improved level of softness and feel for bedding applications, especially if some performance additives are used to promote these properties. Since the available isocyanate is limited or "under indexed," this promotes a

competition for these molecules between the water and the polyol system thereby making the formulation technique very different from conventional urethanes.

With the formulation challenges of viscoelastic foam materials, the processing latitude is one of the most critical. This latitude being very "fine edge" really makes the processing of this foam drastically different from conventional urethanes, and the chemical technology that is used can significantly alter the performance of the product. The foams that result can vary significantly in density as well as firmness. Therefore these foams require very different chemical and or processing approaches as compared to conventional urethane foam. The driving formulation criteria are to specifically control the viscosity (recovery time) of the product to customize the foam's use in bedding platforms. Temperature sensitivity is always an issue as the intent is to have a foam product that operates or maintains its desired firmness in a broad range of ambient temperature conditions. The feel, recovery and firmness of these products can be markedly affected by slight variations in bedroom temperature. If the formulation of the viscoelastic foam is not uniquely adjusted for bedding applications, the viscous nature of the material will also change with time and prolonged use in sleep platform.

An exemplary viscoelastic foam component is a product from Bayer (VE-1000), which has good formulating latitude with 80/20 TDI at 100 index. Of course, other viscoelastic polyols may be used and are known to those of skill in the art. The viscoelastic foam produced using the VE-1000

viscoelastic polyol had excellent shaping conformance and very reduced sensitivity to ambient temperature conditions. This viscoelastic polyol can be used with conventional polyether polyol materials such as ARCOL F-3022, F-3222, F-3040, or P-2000 (Boyer Ultracell Polyl 2000). These polyol streams can be mixed with a conventional high solids polymer polyol material like HS-100, which has been the standard of the industry for many years, to produce a firmer version of the viscoelastic material for high-end mattress compositions. The other additive unique to this viscoelastic product is a foam modifier DP-1022 (Lyondell Chemical) that assists the overall performance of the foam over a wide range of foam densities and firmness. The balance of the formulation for the viscoelastic foam may be composed of standard chemical raw materials that are used in conventional polyether foams, which include silicone surfactant, amine catalyst and flame retardant additives.

The following table lists the formulating materials that give viscoelastic foam its unique properties and the function they contribute to the material. The range levels are well within the formulation expertise of those who are familiar with the formulation criteria for conventional flexible urethane foam.

Component	Range (pph)	Primary Function
VE-1000	50-100	Viscous Character
F-3022	0-50	Elastic Character
HS-100	0-50	Firmness
P-2000	0-50	Firmness
DP-1022	0-3	Damping Character & Strength
TDI (80/20) Index	75-110	Firmness

Pph = parts per hundred parts polyol

Low Density Viscoelastic Formulation Examples

Grade	3 pcf 12 IFD	2.8pcf 15 IFD	3.4 pcf 24 IFD
Component			
VE-1000	70	75	65
F-3022	30	25	
HS-100			35
DP-1022	2.0	1.5	1.5
TDI (80/20) Index	95	100	1.5

The table above shows how manipulation of the key viscoelastic components could be done to alter the density and IFD of some respective low-density materials. A similar set of examples can be developed for High Density materials as well where viscoelastic characteristics are required.

Viscoelastic foams have a unique isocyanate-reaction composition. The mixture typically has a polyester or polyoxyalkylene monol and a polyester or poloxyalkylene triol, usually with a chain extending material or a cross-linker. The monol (polyether or polyester), has one hydroxyl group on each molecule and an average equivalent weight greater than 1000. The average molecular weight of these materials is greater than 1000. In one example, the monol has an average equivalent weight greater than 1500, and in another example an equivalent weight greater than 2000. The hydroxyl number for these materials would be at least about 56 mg KOH/g.

The viscoelastic polyols (like VE-1000) are usually produced by the reaction of a monoalcohol with multiple equivalents of an epoxide material like ethylene oxide (EO) or propylene oxide (PO) and mixtures thereof. These monols can have any desired arrangement of oxyalkylene units where they are PO polymers, EO-capped materials, blocked EO-PO copolymers, random

EO-PO copolymers or PO polymers that are finished with a mixture of PO and EO to arrive at the desired hydroxyl content.

The all PO version of the above monols, that have hydroxyl numbers less than or equal to 56 mg KOH/gm., significantly expand the processing window for making these viscoelastic foam materials. If one were to "EO tip" the above monols, with a mixture of EO and PO and produce a material with 15 to 50 % primary hydroxyl groups, the foam properties and processing of these viscoelastic foams would be significantly improved. The "EO-Capped" version of these monols with high (80 % or greater) primary hydroxyl content are classified as reactive monols and show very high reactivity with isocyanate species. Although all PO monols are great for improved processing latitude, they can tend to make the viscoelastic foam very slick or oily to the touch. The reactive monols can alleviate this oily feel and provide viscoelastic foam with excellent feel and recovery. The polyester or polyoxyalkylene monol (viscoelastic polyol) is used in a range of at least about 15 % to 70 % by weight of the foam mixture based on the amount of isocyanate available in the mixture, with the most another example being a range of 25 – 50 % by weight. This isocyanate-polyol mixture has polyols with functionalities of at least 2 or greater with, for example, a hydroxyl functionality in the range of 3 to 6. The triol materials are one of the species for the viscoelastic foam products discussed here. These polyols have average equivalent weights that are less than 600 or less than 400. The hydroxyl number of these polyols is approximately 94 mg KOH/gm with in one example materials at a hydroxyl number greater than 140 mg KOH/gm.

Other polyols in this case are polyoxyalkylene materials (prepared in a similar manner to monols above but with two or more active hydrogen sites) and are present at a load of 30 to 85 % by weight of the isocyanate mixture but may also be suited for mattress applications at 40 to 70 % by weight of the foam mixture.

In addition to the monol and polyol components, the viscoelastic foam formulations may have either a chain extender or cross linker material to provide increased strength. These materials will be used in the range of 0.1 to 5.0 % by weight or alternatively, .5 to 3.0 % by weight. On a molecular weight basis these chain extenders or cross linkers should be less than 300 g/mole or alternatively, less than 200g/mole.

The isocyanate will have two or more free –NCO groups per molecule, and those that are common to the flexible urethane foam industry include TDI (80/20), TDI (65/35) and MDI (conventional and polymeric), and HDI. The isocyanate component may also be a blend of some or all of the materials noted in the above isocyanate reference. Although good quality viscoelastic foams can be produced in the broad range of isocyanate index for conventional urethanes (85-130), an index for superb quality viscoelastic materials is an isocyanate index below about 110. In one example, the index is about 100.

The following data demonstrates some of the physical properties that are about the same and that are different between various foams that are used in commercial mattresses. The foams are viscoelastic, high resiliency, and conventional formulations.

FOAM PROPERTY DATA
COMMERCIAL MATTRESS FOAMS
VISCOELASTIC-HR-CONVENTIONAL

PROPERTY	VISCOELASTIC	HR	CONVENTIONAL
Density (lbs/cu.ft)	2.8 pcf	2.5 pcf	2.33 pcf
Resilience (%)	11	58	53
Elongation (%)	159	150	348
Tear (pli)	0.8	1.30	1.86
75 % HACS%	5.6	10.7	4.2

The greatest property difference noted is the resilience of the viscoelastic product. With the foam characteristics of slow recovery, body conforming nature, vibration dampening and temperature sensitivity, it can be seen that the viscoelastic product is significantly different from the HR and Conventional materials that have been used in commercial bedding in the past. In an overall view of property characteristics, the HR and conventional urethane foams do not exhibit any of the unique characteristics of the viscoelastic material. These unique properties are a function of the high hydroxyl polyol and polyol blends used along with low index combinations of TDI, MDI and some other specialty isocyanate. In some very unique cases some distinctive silicone surfactants are employed as well as some strength additives to complete the formulation matrix that is different than the conventional flexible urethane system.

Reticulated Viscoelastic Foam

A viscoelastic foam as described earlier herein is subjected to a reticulation process in order to increase the "breathability" of the foam. An intrinsic characteristic of viscoelastic foam is its relative high density and fine cell structure. Reticulation of a viscoelastic foam is obtained by using known thermal reticulation processes that have been used for fine cell, white foam materials. These thermal reticulation processes have enough energy to reticulate the viscoelastic foam. The thermal reticulation processes also have inherent provisions to reduce the amount of scorch that can occur as a result of the combustion nature of the reticulation process in white foams by adjusting the oxygen/hydrogen level during the fuel fill. Specific processes parameters will vary depending on each type of foam that may be used. These process parameters are known to those of skill in the reticulation art.

Analysis has been performed to fully demonstrate the effect of the thermal reticulation process on a viscoelastic foam. The attached table sets forth the physical properties associated with a regular, commercially-available foam (Novacomfort® – Vita). The viscoelastic polyol in this particular foam amounts to approximately 60% of the weight of the finished foam.

Visco-Elastic Foam
Physical Test Results

	Reticulated	Non-Reticulated
Density	3.39	3.43
25% CFD, psi	0.17	0.17
Ball Rebound	10%	11%
Tensile Strength, psi	7.8	8.5
Elongation	170%	220%
Tear Strength, psi	0.7	0.8
Air Flow, cfm	0.96	4

All tests completed according to ASTM D 3574-91

As demonstrated in this table, the significant change in physical properties relates to the air and liquid flow through the foam. The resulting improvement in the air flow in the reticulated viscoelastic foam is greater than four times over an existing, non-reticulated viscoelastic foam.

<u>Comfort Zone Mattress</u>

Figures 1-3 illustrate three examples of foam mattresses 10, 100 and 200 respectively, that include a reticulated viscoelastic foam. Each of these mattresses has multiple layers 50 and multiple zones 40. For the purposes herein, the term "multi-layer mattress" includes a mattress that has more than one layer of material across its length and width in the context of the thickness or depth of the mattress. As shown in Figure 1, there are five layers 50 across the depth of the mattress 10. The layers 50 of the mattress 10 are distinguished from the "zones" 40 of the mattress in that the zones are the longitudinal sections that are shown. As demonstrated in Figure 1,

the mattress 10 has seven zones 40. In other words, the zones 40 are the cross sections of the longitudinal length of the mattress 10 where different foam materials may be used.

The mattresses described in the following, and as shown in the figures, are foam mattresses that incorporates different foam components adhered to each other in order to obtain improved ventilation, durability, and comfort for the mattress. The difference between the mattresses shown in Figures 1, 2 and 3 relate to the number of layers and to the configuration of the inner sections of the zones in the mattresses. In each case, the top or outside layer 20 and 20' in Fig. 1 and 120 and 220 in Figs. 2 and 3 of the mattress 10, 100 and 200 is formed of a latex material. The latex is flexible and durable and has an open cell structure which ventilates well. The purpose of the top layer 20 and 20' in Fig. 1 and 120 and 220 in Figs. 2 and 3 of the mattress 10, 100 and 200 is for comfort and suppleness. An example of an acceptable latex is referred to as a Talalay® Latex. This latex is incorporated as a complete layer that covers the entire length and width of a mattress.

A reticulated viscoelastic foam, for instance the Novacomfort® foam that has been reticulated, is incorporated into two different sections 26 and 26' in Fig. 1 and 126 and 227 in Figs. 2 and 3 in the second layer of the mattresses shown in Figures 1-3. The foam is incorporated for use under the parts of the body where pressure may otherwise build up, for instance the shoulders.

A high resiliency foam (HR 10548 - - Vita-Interfoam, B.V.) is used to support the hip zone 27 and 27' in Fig. 1 and 127 and 227 in Figs. 2 and 3 of the mattress.

A high density polyurethane foam is used in the zones 25 and 25' in Fig. 1 and 125 and 225 in Figs. 2 and 3 of the mattress for the lumbar and head and foot. An acceptable high density foam is a Pantera® 2130HD foam.

The central layer 30 of the mattress shown in Figure 1 (and the bottom layer 130 and 230 of the mattresses shown in Figure 2 and 3) is a reticulated polyurethane foam having a course structure and open cells. The open structure allows for the circulation of air and escape of moisture from the mattress as shown by the arrows in Fig. 1. It also enhances temperature distribution through maximum ventilation. An example of a commercial polyurethane foam acceptable for this use is a Calipore® foam (Caligen Foam, Ltd.) Or EZ-Dri/FilterCrest (Crest Foam Industries). In alternative embodiments, this central layer 30 of Calipore® or open cell polyurethane foam may include a heating element 31 to better dry out and improve the air flow of the mattress.

Each of the mattresses 10, 100 and 200 shown in Figures 1-3 includes a symmetrical zone 40 construction. In other words, the mattress may be turned around head to foot in an ordinary rotation by a user.

In Figure 1, the mattress 10 is further symmetrical across the layers 50. In this way, the mattress 10 may be conveniently flipped or turned around as a result of its symmetry across both its depth and its length. In

one example, the mattress 10 shown in Figure 1 is 200 mm thick (approximately 8 inches). There are five layers 50. There are seven unique zones 40 designed to follow the contour of the body (head/foot, shoulder, lumbar, hip, lumber, shoulder, head/foot). A heating system 31 is incorporated in the middle layer 30 to dry the mattress 10 from the inside and keep it warm during cold nights.

While the invention has been described with reference to specific embodiments thereof, it will be understood that numerous variations, modifications and additional embodiments are possible, and all such variations, modifications, and embodiments are to be regarded as being within the spirit and scope of the invention.